California Regional Water Quality Control Board
Central Valley Region
Robert Schneider, Chair

Dan Skopec,
Acting Secretary

Sacramento Main Office
11020 Sun Center Drive #200, Rancho Cordova, California 95670-6114
Phone (916) 464-3291 • FAX (916) 464-4645
http://www.waterboards.ca.gov/centralvalley

Arnold Schwarzenegger
Governor

Methodology for Derivation of Pesticide Water Quality Criteria for the Protection of Aquatic Life in the Sacramento and San Joaquin River Watersheds.

Phase I: Review of Existing Methodologies
Peer Review Addendum

The University of California at Davis, Environmental Toxicology Department, under contract to the Regional Water Quality Control Board, Central Valley Region (Central Valley Water Board), has completed preparation of a report reviewing methodologies to derive pesticide water quality criteria for the protection of aquatic life (methodology evaluation). The methodology evaluation completes the first phase of a three-phase effort to develop water quality criteria for pesticides that pose a potential water column risk in the Sacramento and San Joaquin River Basins. The methodology evaluation has been peer reviewed by a panel of agency and academic experts. This report presents the Peer Review comments and the responses to those comments.

Description of the Peer Review Process:
In accordance with the contractual scope of work, the project director, Ron Tjeerdema and the contract manager, Joe Karkoski convened a peer review panel to review the major deliverables for this project. The peer review panel includes members of academia and also representatives from partner agencies such as the California Departments of Pesticide Regulation and Fish and Game. The US EPA was also invited to participate in the peer review, but an available and interested reviewer could not be identified.

Based on expertise, availability and interest, the following peer reviewers were selected:

Larry Curtis, Ph.D.
Department Head, Department of Environmental and Molecular Toxicology
Oregon State University

Evan Gallagher, Ph.D.
Associate Professor and Consultant in Toxicology
University of Washington

John Knezovich, Ph.D.
Director, University of California's Toxic Substances Research and Teaching Program

Marshall Lee,
Senior Environmental Research Scientist
Environmental Monitoring Branch
California Department of Pesticide Regulation

Brian Finlayson
Chief, Pesticide Investigations Unit
California Department of Fish and Game
Pesticide Investigations Unit

Peer reviewers were asked to address the following in their review:

a. Accuracy and completeness of the information presented: Are any important methodologies, references or other information missing?

b. Is the approach used to compare and assess methodologies appropriate?

c. Evaluation and interpretation: Are the key features of the methodologies evaluated thoroughly and correctly? Are strengths and weaknesses identified? Are conclusions supported?

d. Are there any scientific issues that should have been addressed in the report, but were not included?

e. Taken as a whole, is the analysis in the report based upon sound scientific knowledge, methods, and practices?

Peer Reviewers were asked to submit their comments directly to the Central Valley Water Board. Once all of the comments were received, Central Valley Water Board submitted the comments to UC Davis for review and response. Responses to peer review comments are included as **Attachment 1**.

To encourage candid comments from the peer reviewers and allow for forthright criticism, comment letters were submitted to UC Davis in a blind fashion. Specifically, minor changes were made to the comment letter text to remove identifying traits. Modifications were largely limited to changes in the header, footer and salutation sections. No modifications were made which could have changed the content of the comments. The compiled comment document is included as **Attachment 2**. Original copies of the comment letters, with identifying information unchanged will be included in the administrative record.

Any questions regarding the peer review process may be directed to Paul Hann at (916) 464-4628 or phann@waterboards.ca.gov, or Joe Karkoski at (916) 464-4668 or jkarkoski@waterboards.ca.gov.

ATTACHMENT 1

Response to Peer Review Comments

This page Intentionally Blank

Response to Peer Review Comments:

Methodology for Derivation of Pesticide Water Quality Criteria for the Protection of Aquatic Life in the Sacramento River Watershed. Phase I: Review of Existing Methodologies

Prepared by Patti L. TenBrook and Ronald S. Tjeerdema

We thank all of the reviewers for their thoughtful and thorough comments on the Phase I report of this project. Following is a point-by-point response to specific comments and suggestions made by each reviewer.

Commenter 1

Comment 1: "The draft report addresses the need for data quality and how various entities approach the issue, but comes to no should conclusion. I suggest that time be spent in developing a data filtering procedure in (the) future."

Response 1: This is an area that is receiving much attention in development of the criteria derivation methodology. Section 6.2.2 of the Phase I report concludes with the following paragraph:

"Detailed data quality requirements must be part of a criteria derivation methodology. Specifics must ensure quality, but should not be so stringent that excessive data are rejected. The Netherlands, USEPA, Canada, Australia/New Zealand and OECD provide good guidance, and elements of these should be considered for inclusion in the new methodology."

No changes will be made to the Phase I report in response to this comment. The new data evaluation procedure will be more rigorous than the AQUIRE system, but will not go so far as to require original test data, as that would lead to excessive rejection, resulting in unnecessarily small data sets.

Comment 2: "In the Executive Summary, the presumption is made that the current methodology for deriving water quality criteria (EPA 1985) will be replaced with the new methodology. This presumption seems biased against the EPA (1985) methodology. "

Response 2: The review was approached without preference or bias toward any method. Any change in methodology will mean a rejection of the USEPA (1985) guidance, since that is the guidance of record at this time. To clarify this, the following has been added to the Executive Summary, as well as to the Conclusion (section 9.0):

"Three possible outcomes of this project are: 1) make no change in criteria derivation methodology (i.e. continue using the USEPA 1985 guidance); 2) adopt one of the other existing methodologies, or; 3) develop an entirely new methodology. Based on this review, the third outcome is most likely."

Comment 3: “Conclusions are made that three methodologies are the most up-to-date and scientifically sound. However, no evidence is offered in the Executive Summary substantiating this claim. This claim again comes up in the Conclusion, but backed by no evidence.”

Response 3: To remove any judgmental statements about which methods are best, the end of the final paragraph of the Executive Summary now reads:

“Among the reviewed methodologies, those from Australia/New Zealand (ANZECC & ARMCANZ 2000), The Netherlands (RIVM 2001) and the Great Lakes (USEPA 2003a) are recommended for comparison to the new methodology in Phase III of this project.”

The end of the final paragraph of the Conclusion now reads:

“Among the reviewed methodologies, those from Australia/New Zealand (ANZECC & ARMCANZ 2000), The Netherlands (RIVM 2001) and the Great Lakes (USEPA 2003a) are recommended for comparison to the new methodology in Phase III of this project. These three methodologies use widely accepted, scientifically defensible, approaches to criteria derivation. The Australia/New Zealand approach builds on that of The Netherlands, while the Great Lakes approach represents an updated version of USEPA (1985) guidelines.”

Comment 4: “When a procedure is proposed in Phase II, I suggest the advantages and disadvantages of each procedure and those of the EPA (1985) procedure be listed by factor in a table.”

Response 4: Again, the intent of this review was not to compare all other methods to the USEPA (1985) procedure, but to objectively evaluate and compare each one to all the others. A table summarizing the key similarities and differences among methodologies is a good idea and such a table, Table 4, has been added to the Phase I Conclusion, along with the following paragraph:

“Table 4 is a summary of differences and similarities between key elements of the six methodologies identified in Table 2. This table highlights the strengths and weaknesses of each methodology in the areas of how data are used to derive criteria, how criteria are derived, and what other factors are considered in the final expression of criteria.”

Comment 5: “…are we to assume that other conditions in the Basin Plan may drive the value of allowable limits, regardless of the WQC derivation procedure? Are there other policies, authorities, regulations and laws that may influence the selection of the WQC derivation procedure?”

Response 5: As stated in the Phase I report:

“The common thread in all of these (different criteria) is that the values derived are scientifically based numbers which are intended to protect aquatic life from adverse effects of pesticides, without consideration of defined water body uses, societal values, economics, or other non-scientific considerations. This corresponds to what the USEPA calls a numeric criterion and it is the derivation of this type of number that is the subject of this report.”

This project has the narrow scope of producing science-based pesticide water quality criteria for the protection of aquatic life. Balancing the results of this effort with other factors that derive from Basin Plan will be the task of Regional Board staff.

Comment 6: “The authors mention in several places that the EPA (1985) procedure makes poor use of available data by using the lowest few values in the data set. It is my understanding that while this usually occurs with small data sets, the procedure uses all the data in large and robust data sets.”

Response 6: Discussions of the USEPA (1985) procedure have been revised to clarify how data sets are used and what effects additional data may have on criteria. Briefly, by this method only the four values nearest the 5^{th} percentile of the data set are used to calculate the Final Acute Value (FAV), but the percentile rankings of those four data are based on the sample size of the entire set. Thus, it is possible to change the FAV simply by increasing the number of data in the set, even if the new data do not fall nearest to the 5^{th} percentile. This issue is discussed further in response to comment #3 made by Commenter 5 (see below), and Phase I report revisions on this issue are indicated there as well.

<u>Commenter 2</u>

Commenter 2 basically summarized the findings of the report and offered concurrence regarding points that should be carried forward for consideration in the new methodology. These points include consideration of temperature effects on pesticide toxicity, exploration of the use of potency factors for assessing compliance when mixtures of similarly acting chemicals are present, and the development of a methodology that incorporates modern approaches to toxicology.

Response: These points will be addressed in Phase II.

<u>Commenter 3</u>

This commenter also provided a lot by way of summary of the Phase I report. A few specific comments were also made.

Comment 1: “It will be important to address in phase 2 particular species of potential concern within the San Joaquin and Sacramento River estuaries with regards to their listing status”

Response 1: Threatened and endangered species will be addressed in Phase II.

Comment 2: “If there will be any consideration to human health protection in the development of the new methodology, it will be important to review the literature with regards to the state of the knowledge of waterborne pesticide exposures on human health.”

Response 2: As noted in response # 5 to Commenter 1, the narrow focus of this project is on derivation of criteria for protection of aquatic life. The only human health component will be to determine if criteria for bioaccumulative pesticides are set at levels that will ensure that FDA action levels will not be exceeded in fish tissue. Further exploration of human health issues is beyond the scope of this project.

Comment 3: “Of particular interest is that the Canadian methodology (CCME 1999) accepts tests with endpoints of pathological, behavioral and physiological effects as secondary data used for derivation of interim guideline values.”

Response 3: Just to clarify, these endpoints are used in the Canadian methodology only if no data are available for endpoints of survival, growth and reproduction. As stated, they are only used to set interim guidelines (i.e., guidelines that are not used in standard setting). The issue of non-traditional endpoints will be explored further in Phase II, but basically, as discussed in the Phase I report, endpoints that are not linked to effects on survival, growth or reproduction should not be used in deriving criteria.

Comment 4: “…the state of California may wish to consider a targeted subset of the more robust biomarkers to be used in a secondary fashion to assess sublethal toxicity….”

Response 4: The methodology developed through this project will present methods for deriving numbers, with some qualitative or quantitative statement regarding their robustness. Whether those numbers are used as criteria, or some kind of secondary, interim values, will be up to Regional Board staff. In Phase II biomarkers will be explored to the extent that studies can be found linking biomarker endpoints to survival, growth or reproduction.

Comment 5: “…the authors may wish to consider publication of this information as a technical report, or in an abbreviated format in the form of a review article for an ecotoxicology journal.”

Response 5: We will consider this.

Commenter 4

Comment 1: “The section on multipathway exposure (7.1.2) only considers exposure via contaminated water and food. Sediment should also be considered as it may be a significant source of contaminants to benthic organisms, especially deposit feeders.”

Response 1: This project is concerned with water column pesticide levels, and as such includes consideration of suspended sediments, but not bedded sediments. Sediment quality criteria are being considered by the Regional Board through a separate project, which, presumably, will consider the effects of ingested sediment on benthic feeders. The new methodology to be developed in Phase II of this project will address the issue of harmonization of criteria between compartments. That is, if sediment criteria are adopted, they should be harmonized with water quality criteria such that neither compartment affects the ability of the other to meet their respective criteria. Beyond that, sources of pesticides to the water column are not within the scope of this project.

Comment 2: A number of editorial corrections were suggested.

Response 2: These have all been fixed, as suggested.

Commenter 5

Comment 1: The reviewer mentions that a California State Water Resources Control Board (1990) report cites a criteria derivation method by Lillebo et al. 1988) and suggests that this method be considered in the Phase I report.

Response 1: Discussions of the Lillebo et al. (1988) report have been included in sections 5.1, 7.2.1.1, 7.2.1.2 and 7.2.2.2 and the article has been added to the list of references.

Comment 2: “Examples of how [splitting data sets or excluding data from species sensitivity distributions] can be done with chlorpyrifos and diazinon…can be found in Giesy et al. (1999) and Norvartis Crop Protection (1997), respectively.”

Response 2: These examples have been mentioned and referenced in the Phase I report and will be consulted in Phase II. Section 7.2.2.4 now contains the following two paragraphs:

“The only criteria methodology that explicitly separates data into groups in constructing SSDs is the USEPA (1985), in which the SSD is constructed using animal data only. Plants are included in criteria derivation, but not directly. If a plant proves to be the most sensitive of species tested, then the final plant value (FPV) is the FCV. All other methodologies combine all aquatic data. The Netherlands methodology even includes NOECs derived from secondary poisoning analysis for birds and mammals (RIVM 2001). However, according to some of the guidelines, if statistical analysis shows that the data do not fit the assumed SSD distribution, or if data show a bimodal distribution, then data may be grouped to achieve a fit, with the most sensitive group used to derive the criterion, or with derivation of separate criteria (RIVM 2001, ECB 2003). In deriving target values by the Australia/New Zealand methodology (ANZECC & ARMCANZ 2000), which involves fitting data to one of several possible distributions, it was possible to use all data sets in their entirety (i.e., with all taxa combined).

The process of grouping and/or exclusion of data has been done in other studies. For example, in constructing an SSD for an ecological risk assessment of chlorpyrifos, Giesy et al. (1999) excluded data from rotifers, mollusks, and other insensitive organisms, although no statistical process was used to determine which data to exclude. Likewise, in a risk assessment of diazinon in the Sacramento and San Joaquin River basins, Novartis Crop Protection (1997) considered 10th percentile values for a combined fish and arthropod data set, as well as for separate fish and arthropod sets. The 10th percentile derived form the combined sets was 3,710 ng/L, while that for the fish alone was 79,900 ng/L and that for arthropods was 483 ng/L. Based on these numbers, combining the fish and arthropod data would lead to an underestimation of risk to arthropods, indicating that the data for the two groups should be analyzed separately."

Comment 3: The reviewer mentions cases in which the California Department of Fish and Game utilized the USEPA species sensitivity distribution method to derive criteria for carbaryl and methomyl even though all eight families were not represented in the data sets (Siepmann & Jones 1998; Menconi & Beckman 1996).

Response 3: These studies have been mentioned in section 6.3 in the discussion of how much data is required by the USEPA methodology. The reviewer referenced these studies in the context of the discussion in section 7.2.1.1 regarding the use of assessment factors to derive criteria. Since the suggested studies did not use an assessment factor method, it is more appropriate to mention them in section 6.3. These studies have also been added to the references.

Comment 4: "The Department of Pesticide Regulation found that physical-chemical values for pesticides are frequently inconsistent and hard to find." The reviewer goes on to suggest a few more sources of physical chemical data, namely the Estimation Program Interface Suite (http://www.epa.gov/oppt/exposure/docs/episuite.htm) and a paper by Laskowski (2002) which provides physical-chemical properties of pyrethroid insecticides.

Response 4: The Phase I report primarily discusses resources used by existing methodologies. In Phase II, a more exhaustive list of resources will be developed. The two suggested resources were reviewed and will be included in the lists of resources for the new methodology.

Comment 5: "In the last paragraph of page 59…the authors state that the US EPA method will most often lower a guideline value--and rarely raise it—with addition of additional data. Later (page 75, paragraph 4), the authors state that additional data will only change the value if additional toxicity values are lower than one of the four original values (i.e., new toxicity data would only lower a criterion if they can be included in the derivation as one of the four lowest genus mean acute values). The authors should clarify this for consistency."

Response 5: This is a very good comment, and several changes have been made to correct and clarify comments about the USEPA (1985) procedure.

1) The comment, "new data may either raise or lower a guideline value (as opposed to the USEPA 1985 method, by which new data will most often lower a value and rarely raise one," has been removed.
2) The following has been added to the end of the second paragraph on p. 59:

"In defense of the USEPA (1985) approach, Erickson and Stephan (1988) argue that, because the entire data set is used in setting percentile ranks and cumulative probabilities, calculation of the FAV using the four data points nearest the 5^{th} percentile does not constitute "not using all the data. They interpret the use of those four data as a means of giving more weight to toxicity values nearest 5^{th} percentile. This weighting leads to other problems, which are discussed in section 7.3.5."

3) The second and third paragraphs of section 7.3.5 now read:

"A recurring theme throughout this review is that ecotoxicity data are generally too scarce to allow for derivation of criteria with a high level of certainty that they will neither over- nor underprotect aquatic ecosystems. Therefore, it would be beneficial if a criteria derivation methodology were designed to encourage data generation by all stakeholders. Okkerman et al. (1991) found that HC_5 values based on data for five species were lower than those based on nine species. This is because the uncertainty in the SSD method decreases with increasing sample size due to lower standard deviations and extrapolation factors.

"Contrarily, for the USEPA (1985) method, which uses only the four values nearest the 5^{th} percentile (the lowest four values in many cases) to calculate the FAV, additional data have different effects, depending upon whether the new data fall within the group of four nearest the 5^{th} percentile. This is illustrated in a report prepared for the California State Water Resources Control Board by the Great Lakes Environmental Center (GLEC 2003). In appendix C of that report, the authors present results of various manipulations of a basic data set. First, with no change to the four values used in calculation of the FAV, simply increasing the number of samples (N) always increases the FAV as the variability in P values of the four data is reduced. Second, as the range of the four values increases (i.e., the variability of the four data increases), the FAV decreases because of the increased variability around the 5^{th} percentile. The problem with the first of these kinds of data set manipulations is that, in an effort to derive higher criteria by the USEPA method, one could simply conduct more tests with insensitive species. Aside from causing the set to violate the log-triangular distribution assumption, such data would drive the criterion upward in a predictable manner, based solely on N, because the new data would not be near the 5^{th} percentile. With other SSD methodologies (i.e., those that do not ignore the upper part of the distribution) the best way to drive a criterion higher is to have a large, balanced data set, such that the variability in the whole set is reduced. By these other methods, if a data set were "padded" with extremely high or low values, outliers and bimodal distributions would be detected and the set would be modified to fix these problems prior to the SSD analysis (ANZECC & ARMCANZ 2000, RIVM 2001, ECD 2003). To encourage generation of balanced data sets, SSD methods that utilize all data (RIVM 2001, ANZECC & ARMCANZ 2000) are preferable."

Comment 4: "Duration and frequency are important elements of water quality criteria. On page 45… the authors state that the U.S. EPA method may be used for a more science-based approach to address duration and frequency components. This suggests that the authors may support the duration and frequency expressions in the U.S. EPA method. On page 43 (paragraphs 1 and 2) however, the authors note that the expressions in the method for acute exposure duration (one hour) and the exceedance frequency (once every three years) seems arbitrary. Clarification would be helpful."

Response 4: The paragraph on page 45 now reads:

"Exclusion of duration and frequency components from criteria statements leaves those two factors solely to policy-based decisions. It would be better if these components could be science-based. The USEPA (1985) format of expressing criteria is a step toward that, but the duration and frequency values used in the acute and chronic criteria statements have little scientific basis. It is possible that a review of more recent literature could strengthen those values. To give risk managers more science-based information would require the use of time-to-event models to determine the duration component, and population models and/or good ecosystem recovery studies to determine the frequency component."

Comment 6: The reviewer suggests a number of things that would make the report more accessible for an audience of diverse stakeholders. Suggestions include more graphics, figures to demonstrate methods, the use of bulleted format in some places, and the inclusion of a non-technical executive summary.

Response 6: Some tables and figures have been added, but not to the extent suggested by the reviewer. This report is rather technical because that is what the Regional Board has asked for. As such, the executive summary is also technical. To simplify the report or the summary too much is beyond the scope of the project. Similarly, in Phase II, the evaluation and selection of models will be technical. However, the methodology itself will be written in a very approachable fashion, with numerous tables and figures to assist users in criteria derivation. The following additions have been made:

Table 4 has been added to the conclusion section to summarize key similarities and differences among the major methodologies.

Figures 1 and 2 have been added to help illustrate SSD concepts.

Comment 7: “I suggest that an effective methodology, as described in section 8.0 of the draft report, should also include an explanation of the method’s assumptions and limitations.”

Response 7: Section 8.0 has been modified to include these components.

References

GLEC. 2003. Draft Compilation of existing guidance for the development of site-specific water quality objectives in the state of California. Great Lakes Environmental Center, Columbus, OH.

This page Intentionally Blank

ATTACHMENT 2

Transmitted Comment Letter

This page Intentionally Blank

CALIFORNIA REGIONAL WATER QUALITY CONTROL BOARD
Central Valley Region
Robert Schneider, Chair

Alan C. Lloyd, Ph.D.
Agency Secretary

Sacramento Main Office
11020 Sun Center Drive #200, Rancho Cordova, California 95670-6114
Phone (916) 464-3291 • FAX (916) 464-4645
http://www.waterboards.ca.gov/centralvalley

Arnold Schwarzenegger
Governor

15 March 2006

Dr. Patti L. Tenbrook
University of California, Davis,
4409 Meyer Hall
Davis, California 95616-8588

Dr. Ronald S. Tjeerdema
University of California, Davis
4139a Meyer Hall
Davis, California 95616-8588

METHODOLOGY FOR DERIVATION OF PESTICIDE WATER QUALITY CRITERIA, PHASE I REPORT – COMPILED PEER REVIEW COMMENTS

Enclosed are the compiled comments received from the 5 peer reviewers on the Methodology for Derivation of Pesticide Water Quality Criteria, Phase I Report. Where necessary, minor changes may have been made to the comment letters to remove identifying traits. The response to the Phase I report has been very positive and your efforts are to be commended.

Prior to making changes to the Phase I report, I would like to arrange a meeting with the project team to discuss these comments. I want to make sure that the comments and proposed document changes are mutually understood and agreed upon; and that any potential impacts to the existing scope of work are addressed.

If you have any questions about this information, please call me. Thanks again for your hard work.

Paul Hann
Environmental Scientist
Pesticide TMDL Unit

Enclosure(s) – 1

PFH/ W:\Staff\phann\Central Valley Pesticide Basin Plan Amendment\WQC Development\Task 2 - Current Method Eval\Peer Review Comment Letters\Compiled Comments.doc

WATER QUALITY CRITERIA METHODOLOGY DEVELOPMENT
Compiled Peer Review Comments on Phase I Report

COMMENTER 1

I have reviewed the draft report entitled, Methodology for Derivation of Pesticide Water Quality Criteria for the Protection of Aquatic Life in the Sacramento River Watershed. Phase I: Review of Existing Methodologies. Overall the information presented was accurate and complete. The authors did a good job of comparing, evaluating and comparing the various methodologies. It is difficult to fault a review that assesses the positive and negative aspects of so many differing procedures. I have just a few comments.

Regardless of which technique is used to derive water quality criteria, the data must be of high quality. Too often attention is paid to the procedure but not to the data that underpin the process. In 2000 and 2001, U.S. Environmental Protection Agency (EPA) under the direction of Dr. Charles Stephan was involved in developing a data reviewing/rating procedure specifically for use in deriving water quality criteria that went beyond that used for AQUIRE (1994). It isn't clear what ever happened to this procedure. The registration procedure for pesticides by EPA and California Department of Pesticide Regulation requires that copies of original test data are submitted. Generally, papers in professional journals without copies of accompanying original data are not acceptable. This high standard allows pesticide regulators to come to their own conclusions on what the data indicate and assures that the test results are high quality data. The draft report addresses the need for data quality and how various entities approach the issue, but it comes to no should conclusion. I suggest that more time be spent in developing a data filtering procedure in future.

In the Executive Summary, the presumption is made that the current methodology for deriving water quality criteria (EPA 1985) will be replaced with new methodology. This presumption seems biased against the EPA (1985) methodology. Conclusions are made that three methodologies are the most up-to-date and scientifically sound. However, no evidence is offered in the Executive Summary substantiating this claim. This claim again comes up in the Conclusion, but backed by no evidence. When a procedure in proposed in Phase II, I suggest the advantages and disadvantages of each procedure and those of the EPA (1985) procedure be listed by factor in a table.

In the Introduction, several sections of the Basin Plan are mentioned but only one of these directly mentions aquatic life. Thus, are we to assume that other conditions in the Basin Plan may drive the value of allowable limits, regardless of the WQC derivation procedure? Are there other policies, authorities, regulations and laws that may influence the selection of the WQC derivation procedure?

The authors mention in several places that the EPA (1985) procedure makes poor use of available data by using the lowest few values in the data set. It is my understanding that while this usually occurs with small data sets, the procedure uses all the data in large and robust data sets.

In closing, the authors are to be commended for writing an in-depth analysis of the WQC derivation procedure.

COMMENTER 2

This document provides an exhaustive review of the procedures whereby regulators of environmental quality in industrialized nations apply toxicological and chemical data to derive criteria for protection of aquatic life from pesticides. It is clearly written with very few typographical errors. Responses to a list of specific questions from the cover letter accompanying the report follow.

A. Accuracy and completeness of the information presented: Are any important methodologies, references, or other information missing?

The report addresses methodologies that derive from more than twelve regulatory bodies. I am quite familiar with the process for development of water quality criteria by the United States Environmental Protection Agency (USEPA). The report accurately and completely describes this methodology. It is apparent that other industrialized nations and commissions/organizations that represent them follow generally similar approaches. Insecticide concentrations that produce no observable or minimally detectable responses (often a 5% change) in aquatic animals and plants are typical data input for criteria derivation. Measures of survival, growth, and reproduction are consistently responses of choice for this data input. The report provides broad coverage of the most recent approaches and considers them in excellent detail. As the report states, non-traditional responses of aquatic life such as changes in enzyme activities are rarely provide data for calculation of water quality criteria. Field and semi-field data are not used in criteria derivation.

B. Appropriateness of the approach used to compare and assess methodologies.

The report systematically compares and contrasts the methodologies industrialized nations apply to derive water quality criteria for pesticides. It is rigorous and illustrates strengths and weaknesses of alternative approaches. It contains a number of examples of formula structures that derive expressions key to development of criteria. These are useful since they permit one to easily identify the kinds of data it is necessary to collect and where default values apply for different methodologies. Comparison and contrast is a highly appropriate approach to assessing these methodologies.

C. Evaluation and interpretation: Are the key features of the methodologies evaluated thoroughly and correctly? Are strengths and weaknesses identified? Are conclusions supported?

The report effectively and completely describes and evaluates principal factors that derivation of water quality criteria consider. For example, LC50 or EC50 data determine USEPA Final Acute Values while results of chronic tests, partial life cycle tests, and early life stage tests determine Final Chronic Values. The analysis of strengths and weaknesses of data deriving from regression analysis versus hypothesis testing studies is important and exhaustive. The conclusion that regression analysis is generally superior to hypothesis testing is useful and cogent. The report applies a consistent, rigorous standard to evaluate methodologies industrialized nations apply for derivation of water quality criteria for protection of aquatic life.

The review of basic criteria derivation methodologies (assessment factor and species sensitivity distribution) is excellent. The report recognizes great uncertainty in application of survival, growth, and reproduction data from a several species after exposures under laboratory conditions to ecosystems. The assessment factor is simply a multiplier for application to numerical criteria deriving from a methodology. The magnitude of the assessment factor increases with scarcity of data. Lack of chronic toxicity data is a common source of uncertainty. Generally, there is a 10-fold increase in assessment factor for each such step in uncertainty increase. There is no empirical basis for this magnitude. This approach is not uncommon, however. Safety factors are part of human health risk assessment under USEPA guidance and closely akin to assessment factors.

The species sensitivity distribution (SSD) provides an alternative approach to assessment factors. This approach analyzes variance in response to toxicants among species. The report identifies a significant advantage of SSD. “When enough data are available, SSD methodologies provide a reasonable way to estimate ecosystem-level effects based on single-species data.”

D. Are there any scientific issues that should have been addressed in the report, but were not included?

The report does a very good job considering some of the environmental factors that influence pesticide toxicity. Sorption to particles, colloids, and dissolved organic matter can significantly reduce pesticide toxicity. The report contains a good analysis of how to deal with sorption to dissolved solids in derivation of criteria. It points out limitations of assuming standard composition as Dutch and German regulators currently do. There is also consideration pH and temperature. Temperature is probably worthy of additional consideration, especially for salmonids and the cold-water insect communities that support them. The Sacramento River Watershed is on the edge of the range for these species, largely due to temperature. Land and water use practices can drive water temperature higher and this can increase uptake rates for lipophilic organic chemicals (chlorpyrifos for example) in both fish and aquatic insects. Interactions of temperature and waterborne pesticides exposures are a potentially important problem.

The observation that USEPA aquatic life criteria do not directly incorporate bioaccumulation is valid. How to deal with this is less clear. The current practice is to separately derive water quality criteria for protection of human and wildlife health that consider bioaccumulation.

Dealing with chemical mixtures is problematic in derivation of criteria. The report discusses use of relative potency factors for additive toxicity analogous to the toxic equivalents approach available for 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin and other planar chlorinated aromatic compounds. It notes addressing these at the compliance stage, not during criteria derivation is common practice. Since many pesticides share a common mode of action (e.g., organophosphate insecticides) it seems exploration of a role for relative potency factors in criteria for the Sacramento River Watershed may be worthwhile.

The report concludes there is usually too little data to derive criteria that are neither under nor over protective. This is a very important and valid point. For example, the 1985 USEPA method only uses 4 values nearest the fifth percentile for a given adverse response. Therefore, criteria can only be driven to lower pesticide concentrations by more data. The objective to design methodology that encourages data generation by all stakeholders is laudable and worthy of development. Utilization of entire data sets allowing derivation of confidence limits for criteria, and encouraging data generation is one approach the report advocates.

E. Taken as a whole, is the analysis in the report based upon sound scientific knowledge, methods, and practices?

Considering current practices in the industrialized nations, the technical basis for the report is solid. It provides a good context for the major aim of the project, improving derivation of numerical criteria for water quality objectives in the Sacramento River Watershed. As the report states, “It is necessary to decide what level of organization is to be protected by water quality criteria.” This will require some thought. The report points out that the use of assessment factors in many existing criteria is a decision that derives from policy rather than empirical science. Great uncertainly in application of data from laboratory toxicity tests with a small number of species to responses in ecosystems drives this caution. Limitations in ability to: extrapolate between species, model exposure conditions including duration, and estimate contributions of bioaccumulation to chronic toxicity, are a few examples. The report lists many more sources of uncertainty. The intent of assessment factors is to provide protection rather than predict a given magnitude of response in aquatic life.

The report is a rigorous and complete review of existing approaches to derivation of water quality criteria for protection of aquatic life. Laboratory bioassay results provide the empirical basis for calculations that provide numerical criteria. The bioassay is a product of 1960s and 1970s research. Current methodologies do not incorporate data from more modern approaches to toxicology. Development of methodologies that permit inclusion of such information is worthy of serious consideration.

COMMENTER 3

I. Overall Summary and General Comments

The goal of the reviewed project was to conduct an extensive literature search to identify criteria derivation methodologies that are either currently in use, or that are proposed for use worldwide. A secondary goal of this phase (phase 1) of the project was to propose modifications of existing methodologies based upon relevant research in ecotoxicology and environmental risk assessment to ensure development of an optimum criteria derivation methodology for the CVRWQCB. Ultimately, one of the highlighted methodologies or more likely, a hybrid criteria derivation methodology, could form the basis for a specific method to protect aquatic life in the Sacramento River and San Joaquin River basins. The technical challenges of identifying critical ecosystem components for protection in the context of these methodologies are also addressed in the phase I document. The project scientists, Drs Tjeerdema and TenBrook, are associated with the Department of Environmental Toxicology at the University of California-Davis, and are well qualified to conduct this evaluation.

The authors took the approach of reviewing existing methodologies from several US states, as well as from different countries, including Australia, Canada, Denmark, the European Union, as well as several other countries. The fact that these countries clearly have different environmental policies is considered in context of the overall goal of the project which is to establish a methodology for determination of pesticide water quality criteria for the protection of aquatic life in the Sacramento River and San Joaquin River basins. The authors ultimately identified six documents that, in particular, contained components that could be used for the development of a methodology for water quality criteria derivation for pesticides in California. These targeted methodologies included approaches that were either widely accepted and currently implemented (USEPA, 1985, RIVM 2001), as well as a more recent criteria approach from Canada (CCME 1999), and newer methodologies with unique aspects relative to the other approaches (USEPA 2003 and EU 2003). This broad based approach by the authors is certainly a strength of the report, especially given that in some environmental pollution scenarios (e.g., such as mitigation of pollutant effects by pulp and paper mill effluents), there are other countries whose experience in this area can be drawn upon for the Sacramento River basin.

The current phase I document was reviewed in the context of the mission of the California regional water quality boards and the water quality control plan for the Sacramento River and San Joaquin River basins. The phase 1 document is responsive to the mission of the California's Regional Water Quality Boards. The surface waters of the targeted basins (Sacramento and San Joaquin rivers) receive pesticide runoff and drainage from several sources including silvaculture, agriculture, residential and industrial stormwater. Accordingly, emphasis will eventually be placed on how the California methodology addresses the protection of biota from the adverse effects of pesticides of relevance to the region and in the context of achieving the lowest levels of nontarget pesticide exposures that are technically and economically achievable.

The authors provide a brief discussion of water quality policy as it pertains to criteria derivation. Following this discussion, a brief but concise review of appropriate criteria types and uses is presented. Issues of site specificity and uncertainty as well as critical components of the ecosystem targeted for protection, data quality considerations and environmental chemistry considerations are addressed. The report is very well-written. It is evident from their discussion that the authors are aware that the derivation of scientifically sound water quality criteria is dependent upon sound environmental chemistry as well as toxicological data originating from diverse taxonomic groups, while at the same time being applicable to those species of relevance in the Sacramento and San Joaquin River basins. This is of particular importance since aquatic species can exhibit markedly different susceptibilities to pesticide injury. The authors clearly evaluated the strengths and weaknesses of the six detailed methodologies in light of the state of the knowledge of ecotoxicology and environmental risk assessment.

The references cited are generally current and appropriate. This reviewer did not detect bias or unfounded extrapolations in the report. The authors should be able to use this information as a basis for the development of a criteria derivation methodology for the San Joaquin and Sacramento River basins. The authors take into account the benefits and shortcomings of applications of the precautionary principle to the establishment of water quality criteria and preventive prevention of environmental damage.

At the close of their study (section 9.0), the authors conclude that; 1) water quality criteria may be derived from single species toxicity data and statistical extrapolation for data of adequate size, or by the use of empirically based assessment factors when data sets size is not a limitation, 2) assessment factor methods are relatively conservative and thus have a low probability of underestimating risk with a concomitant high probability of overestimating risk, 3) extrapolation methods may also under- or overestimate risk, but in a quantifiable manner. The authors also conclude that methods are also available for criteria derivation using multi-species toxicity data, although this is rare given the questionable nature of acceptable data. Such conclusions are supported by the literature cited. The authors recognize the uncertainty associated with limitations of the current state of the science and specifically with difficulties associated in assessing the toxicity of mixtures and of multiple stressors. Of note is the fact that the authors identified methodologies that address these issues through additional assessment factors. The authors conclusion that “no single existing methodology is ideal, but that elements of several could be combined along with newer risk assessment tools into a flexible criteria derivation procedure that can produce protective criteria” (P. 77), is reasonable and can underlie the approach for the second phase of the project. In this regard, the second phase of the project will build upon these elements and further explore models appropriate for the derivation of protective criteria for the San Joaquin and Sacramento basins.

In summary, the rationale and approach for this initial survey assessment of other criteria methodologies for the eventual purpose of establishing a water quality criteria methodology applicable for the San Joaquin and Sacramento River basins appears to be scientifically sound. This, given the fact that there are demonstrated data gaps in the ecotoxicity literature with regards to the effects of mixtures, multiple stressors, and also a potential lack of specific data on some aquatic species of relevance to the Sacramento River basin. The document represents a reasonable approach and a sound basis for the latter phases of the project which will be completed by the fall, 2006. The fact that the authors recognize that the “strongest of criteria derivation methodologies must be understandable and usable by environmental managers” (p. 76) is a key observation that provides additional confidence that a successful methodology can be developed by this group for the Sacramento River basin.

II. Critique of Specific Elements of the Document.

A. Accuracy and Completeness of the Information Presented.

The current report constitutes a survey of existing criteria derivation methodologies that are of relevance to developing a plan for the Central Valley Regional Water Quality Control Board. While it is not reasonable to include a review of all existing water quality criteria derivation methodologies, the authors clearly have conducted an exhaustive review of the water quality criteria literature and selected several appropriate methodologies for a more in-depth analysis. The evaluations appear to be technically accurate, and in instances where modifications of existing methodologies are proposed, such modifications appear to be based on the recent literature and are scientifically reasonable. All material included in the document is appropriately referenced. The references included articles from ecotoxicology journals, published books, textbooks in the areas of environmental chemistry and ecotoxicology, technical documents and guidance documents. References that were not current (e.g. those prior to 2000) were appropriate for evaluating the scientific basis of the reviewed methodologies.

B. Appropriateness of the approach used to compare and assess water quality criteria methodologies.

The authors approach included a review of the criterion and description for each methodology in the context of those components necessary to be addressed by criteria, including protection levels, ecotoxicity and physical chemical data, and numeric calculations. The approach used by the authors to compare and assess water quality criteria methodologies is reasonable and appropriate. For example, the contrasting of criteria derivation methodologies (sections 4.0-4.2) in the context of important levels of biological organization targeted for protection, is fairly presented. In this regard, the authors recognize that criteria need to be developed that are protective of representative key species from a variety of trophic groups. The fact that criteria targets may differ among countries with varying environmental policies is noted, but more importantly, is evaluated in the context of the mandate of the Central Valley Regional Water Quality Control Board (i.e. maintenance of water, free of toxic concentrations at those levels deemed to produce detrimental physiological responses in human, plant, animal, or aquatic life, CVRWQCB, 2004).

All of the methodologies evaluated appear to rely to a great extent upon single species toxicity data to derive criteria. This approach is inherit upon the assumption that ecosystem sensitivity is dependent upon the most sensitive species, and also that protection of ecosystem structure protects community function. However, the authors discuss these assumptions within the concept of ecosystem redundancy, that is, that ecosystems can sustain some will level of stress from toxic and are non-toxic and stressors without loss of function (p. 11).

The issue of uncertainty surrounding the application of water quality criteria in the context of statistical probability of over- or under- protection is thoughtfully discussed, especially in the context of providing environmental managers with a working sense of the reliability of criteria. Unfortunately, as the authors point out, this issue is hampered by the lack of high-quality ecotoxicity data for numerous species at different levels of ecosystems.

Another strength of the report is the fact that the authors consistently offer grounded alternatives based upon recent research in ecotoxicology to offer improvements upon the methodologies that are either currently in use or are proposed for use. Such modifications may help reduce the uncertainty associated with the establishment of water quality criteria derivation for the San Joaquin and Sacramento Rivers in phase 3 of the project.

C. Evaluation and interpretation of the various water quality methodologies reviewed.

All methodologies are evenly discussed with regards to levels of biological organization, probabilities of over- or under- protection of key species, data sources, physical chemical and ecotoxicity data quality, etc. The various methodologies appear to have been carefully evaluated and fairly critiqued. The strengths and weaknesses of each of the methodologies are appropriately identified and the conclusions drawn by the authors appear to be supported by the literature presented.

D. Scientific issues of relevance that were not addressed in the current report

In general, this reviewer could find no major scientific issues of relevance that were not addressed in the current report. For example, issues sometimes glossed over in methodologies of establishing water quality criteria (e.g. biochemical, and physiological biomarker endpoints, complex mixtures, numeric issues of sample size, endangered or threatened species, secondary poisonings due to bioaccumulation) are given consideration in the report. It will be important to address in phase 2 particular species of potential concern within the San Joaquin and Sacramento River estuaries with regards to their listing status. In addition, issues of uncertainty may also be approached by identifying local species that may reside on the relative resistant or highly susceptible ends of the spectrum with respect to pesticide toxicity. The authors clearly have the scientific expertise for such analyses. It was not clear to this reviewer if the eventual methodology for the Sacramento River watershed will entirely focus upon aquatic life, as opposed to human health. If there will be any consideration to human health protection in the development of the new methodology, it will be important to review the literature with regards to the state of the knowledge of waterborne pesticide exposures on human health.

As discussed, non-traditional endpoints (pages 34-37) is an area of considerable debate in applied ecotoxicology and is thoughtfully addressed by the authors. The authors' statement that "studies showing a predictive relationship between biochemical, behavioral or other nontraditional endpoints, and population, community or ecosystem level effects, are rare" and that "more research is needed before nontraditional toxicity tests endpoints can be used as general predictors of ecosystem no-effect levels (p. 37)" is reasonable. The authors carefully point out that many of these nontraditional endpoints are more sensitive than established toxicity endpoints, but have not been clearly linked to effects of the population, community or ecosystem levels. Accordingly, such endpoints have rarely been used for derivation of water quality criteria and may not relevant for the state of California at this time. However, it also should be noted that this is an area of scientific debate and that there has been considerable progress in potential applications to ecological risk assessment and natural resource damage assessment. Of particular interest is that the Canadian methodology (CCME, 1999) accepts tests with endpoints of pathological, behavioral and physiological effects as secondary data used for derivation of interim guideline values.

The state of the science for some of these markers has rapidly improved with advances in technology and also our better understanding of biochemical processes. For example, there is increasing evidence that some of these biomarkers (e.g. DNA damage, histopathological injury, neurobehavioral dysfunction) may indeed reflect chemical stress that can threaten survival through important behaviors such as feeding, predator prey avoidance. Such sublethal injuries are typically not accounted for by traditional toxicity testing, but are of value in a qualitative sense. In general, biochemical markers such as changes in cytochrome P4501A- dependent or glutathione S-transferase activities may reflect chemical exposures if specific biochemical assays are employed. In particular, CYP1A activity has proven to be a "universal" biomarker of aromatic hydrocarbon exposure and does not respond to other stressors in any appreciable manner. However, these enzymatic activities are poorly linked to whole animal and population effects, and are probably not appropriate for pesticide exposures. Although the sublethal injuries detected by certain biomarkers are not detected in traditional toxicology testing, they can still threaten the survival of the individual. Accordingly, the state of California may wish to consider a targeted subset of the more robust biomarkers to be used in a secondary fashion to assess sublethal toxicity, such as those markers used in Canada in assessing the effects of pulp and paper mill pollution. It is likely that such biomarkers will prove most useful in the assessment of complex mixtures, as they tend to integrate and reflect cell injury from multiple exposures.

Scientific soundness of the analysis of the report

It is the reviewer's opinion that this report is scientifically sound, especially when considered in the context of the state of the scientific knowledge in ecological methodologies and ecotoxicity research. The information presented in this initial report could be of benefit to environmental managers and regulators who work in this area. Accordingly, the authors may wish to consider publication of this information as a technical report, or in an abbreviated format in the form of a review article for an ecotoxicology journal

COMMENTER 4

I have reviewed the draft report authored by Patti Tenbrook and Ron Tjeerdema, entitled "Methodology for Derivation of pesticide Water Quality Criteria for the Protection of Aquatic Life in the Sacramento River Watershed, Phase I: Review of Existing Methodologies." It is my understanding that this report constitutes the first product of a water quality criteria derivation project and is intended to provide a comprehensive review of water quality criteria derivation methodologies that are currently in use or are proposed. This report is intended to describe key features of each methodology, identify evaluation criteria for each methodology, and define each methodology's strengths and weaknesses.

I have found this report to be a substantial and comprehensive review of methods for the derivation of water quality criteria. The authors have performed a rather exhaustive survey of available methodologies and have accurately summarized their key features and components. While pointing out the strengths and weaknesses of individual approaches, they have clearly revealed that there is not a single consensus approach for deriving water quality criteria. They intentionally stopped short of discussing the feasibility of implementing any of these approaches, which they will address in the next report.

I found only one section of the report that could benefit from an expanded discussion. The section on multipathway exposure (7.1.2) only considers exposure via contaminated water and food. Sediment should also be considered as it may be a significant source of contaminants to benthic organisms, especially deposit feeders. I understand that quantitative guidance for setting criteria based on sediment concentrations is lacking, and the authors should point this out in section 7.1.2. Although the following section (7.1.3) describes water quality characteristics that include interactions of contaminants with suspended solids, the potential role of bedded sediments as a source of contaminants is not addressed there either.

This report is largely a compilation and overview of existing methods, and as such, it does not contain original conclusions. Accordingly, I have no comment on its originality or the soundness of the conclusions but attest that they are a fair representation of work performed by others. Instead, this report provides a sound reference for the derivation of a water quality methodology for the Sacramento and San Joaquin River basins, which will be a product of the next phase of this work.

For completeness, I have identified a number of relatively minor items that should be corrected in the final report:

- Page 14, 2nd paragraph, line 5: "Kow" should be "log Kow"
- Page 14, 3rd paragraph, line 9: "provide" should be "provided"
- Page 14, 4th paragraph, line 3: "form" should be "from"
- Page 17, 4th paragraph, line 4: There is a statement that "if the test duration was too short given the Kow and/or BCF then acute tests are not acceptable and only chronic data may be used." This statement should specifically state the test duration Kow value that would trigger the need for chronic evaluations. This information is included later (on page 27), but should also be listed here.
- Page 15, 4th paragraph, line 7: "Y of N" should be "Y or N"

- Page 27, 1st paragraph, line 4: “Kow” should be “log Kow”
- Page 28, 1st paragraph, line 4: A verb is needed at the end of the sentence (…a plant study of unspecified duration is required).
- Page 29, 4th paragraph, line 1: Add a comma after i.e. (i.e.,)
- Page 42, 1st paragraph, line 11: Delete the period after population-level effects
- Page 47, 2nd paragraph, line 3: Add a comma after e.g. (e.g.,)
- Page 55, 1st paragraph, line 1: Delete duplicate “used in”
- Page 56, 1st paragraph, line 5: “on” should be “one”
- Page 75, 1st paragraph, line 1: Add a comma after e.g. (e.g.,)

Overall, this report provides a sound foundation for the next phase of this study and I look forward to reviewing that document. Please do not hesitate to contact me if you have any questions.

COMMENTER 5

Thank you for the opportunity to review the draft report, "Methodology for Derivation of Pesticide Water Quality Criteria for the Protection of Aquatic Life in the Sacramento River Watershed, Phase I: Review of Existing Methodologies." When Dr. Patti TenBrook, University of California, Davis, requested my review, she asked me to respond to specific questions related to the draft report. My responses are presented below.

A. Accuracy and completeness of the information presented: Are any important methodologies, references or other information missing?

For the sake of completeness, the authors should consider adding information on other efforts that relate to the development of water quality criteria for pesticides in Central Valley waterways.

- California State Water Resources Control Board (1990) cited a method described in Lillebo et al. (1988) when it proposed water quality criteria for the herbicides molinate and thiobencarb in the Sacramento River. This method was reportedly used to develop other water quality criteria as well, some of which were adopted as water quality objectives. The method involves determining the "conservative estimate of chronic toxicity," which is defined as the log mean of the three lowest observed effect concentrations (LOECs) from acceptable chronic toxicity studies. With this method, it is permissible to group toxicity values from plant and animal species among the three LOECs. Margins of safety may be applied, and in the case of criteria for molinate and thiobencarb, the conservative estimate of chronic toxicity was multiplied by 0.1. The criteria were expressed as 14-day running averages. The authors provided rationale for their preference for this method over the U.S. Environmental Protection Agency's (U.S. EPA's) standard methodology (U.S. EPA 1985). The Central Valley Regional Water Quality Control Board's current performance goals for molinate and thiobencarb are based on preliminary criteria suggested by authors of the 1990 report. Thus, this is another method, aside from the Canadian methodology described in the draft report, that uses chronic LOEC values.

- The draft report mentions (on page 66) that when the Dutch and the European Union confront asymmetric toxicity distribution data, they may split the data into two distributions and use the more sensitive distribution. Examples of how this can be done with chlorpyrifos and diazinon–pesticides of particular interest to the Central Valley Regional Water Quality Control Board–can be found in Giesy et al. (1999) and Novartis Crop Protection (1997), respectively.

- On page 52, the authors discuss adjustments that may be made to the method recommended by U.S. EPA (1985) when a full complement of toxicity data are not available. In their series of hazard assessments of various pesticides to aquatic organisms, the California Department of Fish and Game sometimes proposed interim criteria, even though not all of the eight taxonomic categories were represented with toxicity data. In some of these cases (e.g., Siepmann and Jones's [1998] assessment of carbaryl and Menconi and Beckman's [1996] assessment of methomyl), it was noted that toxicity data for mollusks or rotifers were needed to round out the eight taxonomic categories. The assessments noted, however, that these organisms are typically not very sensitive to insecticides and that the additional data would likely not lower the criteria.

Additional information the authors should consider:

- The Department of Pesticide Regulation found that physical-chemical values for pesticides are frequently inconsistent and hard to find. The authors of the draft report may be interested to know that U.S. EPA sponsored the development of a collection of models, known as the Estimation Program Interface Suite, that estimates physical-chemical values and environmental fate for pesticides. Information on these models can be found at the Web site <http://www.epa.gov/oppt/exposure/docs/episuite.htm> and might fit in the draft report's discussion on pages 22–24. Additionally, a good resource for physical-chemical properties of pyrethroid insecticides is Laskowski (2002). For the sake of completeness, the authors may want to cite these references and comment on their utility.

- In the last paragraph of page 59 (which continues on page 60), the authors state that the U.S. EPA method will most often lower a guideline value–and rarely raise it–with the addition of additional data. Later (page 75, paragraph 4), the authors state that additional data will only change the value if additional toxicity values are lower than one of the four original values (i.e., new toxicity data would only lower a criterion if they can be included in the derivation as one of the four lowest genus mean acute values). The authors should clarify for consistency.

- Duration and frequency are important elements of water quality criteria. On page 45 (near the bottom) the authors state the U.S. EPA method may be used for a more science-based approach to address duration and frequency components. This suggests that the authors may support the duration and frequency expressions in the U.S. EPA method. On page 43 (paragraphs 1 and 2), however, the authors note that the expressions in the method for acute exposure duration (one hour) and the exceedence frequency (once every three years) seem arbitrary. Clarification would be helpful.

B. Appropriateness of the approach used to compare and assess methodologies

As described in the introduction, this report will set the stage for the development of a methodology that can be used to derive pesticide water quality criteria for the Sacramento River watershed. This project will likely have high visibility and a diverse group of stakeholders with varying backgrounds will want to meaningfully participate in the process. If all stakeholders do not understand and appreciate the scientific underpinnings of the criteria–and ultimately water quality objectives–their acceptance of and participation in subsequent efforts to improve water quality could be put at risk. The authors should try to make the report more accessible by adding graphics and capturing essential information in synoptic form, bulleted lists, or tables. For example, Table 2 is very helpful; perhaps it can be expanded or supplemented with other tables to explain the authors' interpretation of each method's strengths and weaknesses, key assumptions, etc. Figures that demonstrate how some of the techniques (e.g., species sensitivity distribution techniques) are used would also be very helpful. The conclusion section should more succinctly capture the key findings of the review, perhaps in numbered or bulleted format. Similarly, a nontechnical executive summary should be added. (These are only examples and represent only a partial account of refinements that could help make the report easier to use for stakeholders). Such additions should be possible without sacrificing the objectivity of the report.

Additionally, I suggest that an effective methodology, as described in section 8.0, of the draft report should also include an explanation of the method's assumptions and limitations.

C. Evaluation and interpretation: Are the key features of the methodologies evaluated thoroughly and correctly? Are strengths and weaknesses identified? Are conclusions supported?

The authors presented the various methodologies objectively and with enough detail for readers to generally understand them. Each method will have nuances that can only be appreciated by those that have a lot of experience with each method's application. Understandably, that level of detail has to be beyond the scope of a review like this.

D. Are there any scientific issues that should have been addressed in the report, but were not included?

Aside from the qualifications noted above, I thought the report was complete and appropriately sets the stage for Phase II of the project: proposing an appropriate methodology for developing water quality criteria for Sacramento Valley waters.

E. Taken as a whole, is the analysis in the report based upon sound scientific knowledge, methods, and practices?

Yes. The report was well researched, and the references were objectively reviewed.

As a final comment, I thought the draft report was very well written and organized. It will be a very valuable resource for Phase II and Phase III of this project and should be valuable to other Regional Water Quality Control Boards–and even other states–that are grappling with water quality issues related to pesticides.

I hope these comments are helpful. Please feel free to contact me if you have any questions.

References Cited By Commenter 5

California State Water Resources Control Board. 1990. Sacramento River toxic chemical risk assessment: Final project report. Report 90-11WQ. Sacramento, CA.

Giesy, J.P., K.R. Solomon, J.R. Coates, K.R. Dixon, J.F. Giddings, and E.E. Kenaga. 1999. Chlorpyrifos: Ecological risk assessment in North American aquatic environments. Rev. Environ. Contam. Toxicol. 160:1-129.

Laskowski, D.L. 2002. Physical and chemical properties of pyrethroids. Rev. Environ. Contam. Toxicol. 174:49-170.

Lillebo, H.P., S. Shaner, D. Carlson, and N. Richard. 1988. Water quality criteria for selenium and other trace elements for protection of aquatic life and its uses in the San Joaquin Valley. *In*: Technical Committee Report: Regulation of agricultural drainage to the San Joaquin River. Appendix D. California State Water Resources Control Board, Sacramento, CA.

Menconi, M. and J. Beckman. 1996. Hazard assessment of the insecticide methomyl to aquatic organisms in the San Joaquin river system. Admin. Rep. 96-6. California Department of Fish and Game, Environ. Serv. Div., Rancho Cordova, CA.

Novaris Crop Protection. 1997. An ecological risk assessment of diazinon in the Sacramento and San Joaquin River basins. Novartis Crop Protection, Environ. and Public Affairs Dep. Tech. Report 11/97. Greensboro, NC.

Siepmann, S. and M.R. Jones. 1998. Hazard assessment of the insecticide carbaryl to aquatic organisms in the Sacramento-San Joaquin river system. Admin. Rep. 98-1. California Department of Fish and Game, Office of Spill Prevention and Response, Rancho Cordova, CA.

U.S. Environmental Protection Agency. 1985. Guidelines for deriving numerical national water quality criteria for the protection of aquatic organisms and their uses. PB85-227149. U.S. Department of Commerce, National Technical Information Service, Springfield, VA.